electronic signals representative thereof and signal transmission means for delivering the electronic signals to the computer means, the improvement comprising:];

a motor [means] connected to rotate the end effector about the end effector axis [and] to thereby provide a yaw [(Y)] motion;

[wherein the sensor means further includes means for sensing the Y-motion and creating an electronic signal representative thereof;

wherein the signal transmission means further includes means for delivering the electronic signal representative of the Y-motion to the computer means]; and

[wherein the electronic computer means further includes] means for monitoring and controlling the [Y-motion] yaw motion such that the end effector can be moved in a straight line which is not restricted to the radial direction.

2. (Amended) The robotic arm structure of claim 1 wherein the [electronic computer] monitoring and controlling means further includes [means for] monitoring and controlling the [θ-, R-, Z- and Y- motions] θ motion, R motion and yaw motion such that the distal end portion of the distalmost of the links can be moved in arbitrary continuous paths, including multisegment [smooh] smooth trajectories and straight lines, which are not restricted to a radial direction while maintaining a prescribed orientation of the end effector.

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5. (Amended) A plurality of arm structures in accordance with claim 1, each having one or more work stations within its reach, the arm structures being [position] positioned sufficiently close together such that after a workpiece has been transported to one of the work stations within reach of a first of the arms and processed, it is then transported by the first of the arms to a transfer station which is also within the reach of the second of the arms for processing at work stations within the reach of the second arm.

6. (Amended) A sensor array located in a position such that a workpiece being transported by [an] the arm structure as set forth in claim [1] 2 passes over the sensor array whereat any deviation in alignment of the workpiece, if present, is determined and an electronic error signal is generated and communicated to the [electronic computer] monitoring and controlling means [which controls the arm] to make the appropriate [R-, θ- and Y-] θ motion, R motion and yaw motion corrections to properly align the workpiece.

B2 Cont'd.

7. (Amended) A robotic arm system as set forth in claim 1, further [characterized in including] comprising:

at least one additional end effector [pivotally mounted for rotation relative] attached to the [distal end portion of the] distalmost link [about the end effector axis]; and

an additional motor [means] connected to rotate each additional end effector [about the end effector axis and] to thereby provide a yaw [(Y)] motion for the additional end effector;

wherein the [sensor] monitoring and controlling means further includes means for [sensing] monitoring and controlling the [Y-motion] yaw motion of the additional end effector [and creating an electronic signal representative thereof;

wherein the signal transmission means further includes means for delivering the electronic signal representative of the Y-motion of the additional end effector to the computer means; and

wherein the electronic computer means further includes means for monitoring and controlling the Y-motion of the additional end effector such that the additional end effector can be moved in a straight line which is not restricted to the radial direction].

B3

15. (Amended) A robotic arm mechanism adapted to manipulate workpieces which provides R, θ and ~~[Y (yaw)]~~ yaw motion, comprising:

two pairs of linkages, each linkage having a proximal link having proximal and distal end portions and a distal link having proximal and distal end portions, the distal end portion of the distal link of each of the pairs of linkages being pivotally [mounted] connected at a distal axis [to one another] the distal end portion of each proximal link being pivotally [mounted] connected to the proximal end portion of the corresponding distal link at a respective elbow axis, the proximal end portion of each proximal link being pivotally [mounted] connected at a respective shoulder axis to a [relatively static] support and in spaced apart relation to one another;

an end effector [mounted at the distal end portion of] attached to the distal links [for pivotal motion] and being rotatable about [the distal] an end effector axis, all of the [pivotal] axes being parallel to one another [and extending in a first direction], the links and the end effector being spaced from one another along the direction of the axes such that the [links] end effector can be moved orthogonally to the support and the links over the support [the first direction in a volume extending along the first direction] without obstruction from one another;

a yaw motor connected to drive relative rotation of the end effector about the [distal] end effector axis;

an elbow motor connected to drive relative rotation between the proximal end portion of a respective one of the distal links and the distal end portion of the corresponding proximal link; and

a shoulder motor connected to drive rotation of the proximal end portion of one of the proximal links relative to the [static structure] support.

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17. (Amended) A robotic arm mechanism as set forth in claim [16] 15, wherein the elbow motor is connected to drive rotation in a respective one of the linkages and the shoulder motor is connected to drive rotation in a respective other of the linkages.

18. (Amended) A robotic arm mechanism, as set forth in claim 15, wherein the yaw motor is mounted to the [relatively static structure] support generally along a respective one of the shoulder axes and the shoulder motor is mounted to the [relatively static structure] support generally along the same shoulder axis, the mechanism further including a belt and a pulley [means] for transmitting rotational motion from the yaw motor to the [distal axis] end effector, the elbow motor being mounted to a respective other of the shoulder axes, the mechanism further including a belt and a pulley [means] for transmitting rotational motion from the elbow motor to the elbow axis.

31. (Amended) [In a] A robotic arm structure [having θ-, R- and Z-motors for] providing [θ-, R- and Z-motions] θ motion and R motion about a primary axis, the arm structure [having] comprising:

an end effector [portion thereof pivotally mounted for rotation] attached to the arm structure and being rotatable about an end effector axis [which is parallel to the primary axis, the arm structure being controlled by electronic computer means controlling the θ, R- and Z- motors and thereby the corresponding motions, sensor means for sensing the R, θ- and Z- motions and for creating electronic signals representative thereof and signal transmission means for delivering the electronic signals to the computer means, the improvement comprising:];

[means for providing] a first motor connected to rotate the end effector about the end effector axis to provide a yaw [(Y) and] motion; a second motor connected to rotate the end effector to provide a roll [(E)] motion of the end effector;

[workpiece orientation determining means for determining the orientation of a workpiece which is to be picked up by the end effector and for creating an error electronic signal representative thereof;

means for transmitting the error signal to the computer means;

wherein the computer means includes] and means for [computing corrections to be applied to the R, θ, Z, Y, and E] monitoring and controlling the yaw and roll motions [such that the workpiece can be picked up and transported by the end effector in a desired orientation].

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35. (Amended) [In a] A robotic arm structure [having θ-, R- and Z-motors for] providing [θ-, R- and Z-motions] θ motion and R motion about a primary axis, the arm structure [having] comprising:

an end effector [portion thereof pivotally mounted for rotation] attached to the arm structure and being rotatable about an end effector axis [which is parallel to the primary axis, the arm structure being controlled by electronic computer means controlling the θ-, R- and Z-motors and thereby the corresponding motions, sensor means for sensing the R, θ- and Z-motions and for creating electronic signals representative thereof and signal transmission means for delivering the electronic signals to the computer means, the improvement comprising:

an elevator moveable along the Z axis, the robotic arm structure being supported by the elevator;

means for controllably tilting the elevator about any axis lying in a plane orthogonal to the Z axis;

means for providing yaw (Y), roll (E) and/or pitch (J) motion of the end effector;

workpiece orientation determining means for determining the orientation of a workpiece which is to be picked up by the end effector and for creating an error electronic signal representative thereof;

means for transmitting the error signal to the computer means;

wherein the computer means includes]; a first motor connected to rotate the end effector about the end effector axis to provide a yaw motion;

a second motor connected to rotate the end effector to provide a roll motion of the end effector;

a third motor connected to rotate the end effector to provide a pitch motion of the end effector; and

means for [computing corrections to be applied to control the tilting of the elevator, to the R, θ and Z motions and to one or more of the Y, E, and/or J] monitoring and controlling the yaw, roll, and pitch motions [such that the workpiece can be picked up and transported by the end effector in a desired orientation].

39. (Amended) [In a] A robotic arm structure [having θ-, R- and Z-motors for] providing [θ-, R- and Z-motions] θ motion and R motion about a primary axis, the arm structure [having] comprising:

an end effector [portion thereof pivotally mounted for rotation] attached to the arm structure and being rotatable about an end effector axis [which is parallel to the primary axis, the arm structure being controlled by electronic computer means controlling the θ-, R- and Z- motors and thereby the corresponding motions, sensor means for sensing the R, θ- and Z- motions and for creating electronic signals representative thereof and signal transmission means for delivering the electronic signals to the computer means, the improvement enabling picking up and transporting workpieces in cassettes located in a planar region generally parallel to the Z axis, comprising:];

[means for providing] a first motor connected to rotate the end effector about the end effector access to provide a yaw [(Y) and] motion; a second motor connected to rotate the end effector to provide a pitch [(J)] motion of the end effector;

[workpiece orientation determining means for determining the orientation of a workpiece which is to be picked up by the end effector and for creating an electronic signal representative thereof;

means for transmitting the signal to the computer means;

wherein the computer means includes] and means for [computing corrections to be applied to control the R, θ, Z, Y and J] monitoring and controlling the yaw and pitch motions [such that the workpiece can be picked up and transported by the end effector in a desired orientation].

Add the following new Claims:

-- 44. The robotic arm structure of claim 31, wherein the end effector has at least two hands such that the second motor rolls a first hand and a third motor rolls a second hand.

10. 9
45. The robotic arm structure of claim 44, further comprising:

a first pitch motor connected to rotate the first hand to provide a pitch motion of the first hand; and

a second pitch motor connected to rotate the second hand to provide a pitch motion of the second hand.

12. 11
46. The robotic arm structure of claim 35, further comprising:

a tiltable support having the arm structure thereon.

13. 11
47. The robotic arm structure of claim 35, further comprising:

a telescoping tiltable support having the arm structure thereon.